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# Role of Obstetric Ultrasound in Reducing Maternal and Neonatal Mortality in Developing Countries: From Facts to Acts

Vedran Stefanovic

## ABSTRACT

World Health Organization antenatal care recommendations include an ultrasound scan as a part of routine antenatal care. The impact of routine ultrasound imaging in terms of significantly improving the overall pregnancy outcome has been disputed by recent Cochrane review based on trials conducted mostly in developed countries. When ultrasound is used in high-risk pregnancies, its use becomes clearly beneficial. However, the fatal pregnancy outcomes (stillbirth, maternal, and early neonatal death) as end points are considerably rare in developed countries, while it must be highlighted that developing countries account for 99% of maternal and neonatal mortality. Also, considering the fact that there are no sufficient studies conducted in developing countries, particularly in rural settings and high-risk pregnancies, it is still unclear whether some positive impact as described in developed countries will produce similar results in low-income countries with specific problems and needs. This review not only provides further evidence of the promising potential of the use of ultrasound in resource-limited settings but also addresses some critical issues of maternity care in developing countries. Also, certain proposals and ideas about how to implement ultrasound in clinical practice to reduce maternal and neonatal mortality will be discussed.

**Keywords:** Cesarean delivery, Low-income countries, Maternal mortality, Neonatal mortality, Sub-Saharan Africa, Ultrasound.

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## INTRODUCTION

The use of obstetric ultrasound has gained irreplaceable role in the screening for common fetal aneuploidies, preeclampsia, preterm birth and diagnosis and management of structural abnormalities, multiple pregnancies, placenta previa (PP), vasa previa, and many other obstetrical entities. Obstetric ultrasound is also of essential importance in minimally invasive fetal surgery procedures (e.g., intrauterine transfusions and fetal shunting) and essential part of diagnostic procedures in fetal medicine (amniocentesis, chorionic villus sampling, and cordocentesis for different indications). Routine obstetric scanning refers to regular ultrasound imaging for each pregnancy conducted either at the first, second, or third trimester to separate specific pregnancy abnormalities from normally progressing pregnancies.<sup>1</sup>

In Western medicine, routine obstetric ultrasound has achieved almost universal coverage and is a routine part of accepted antenatal care, especially in Scandinavian countries with high uptake rate and state-funded maternity care.<sup>2</sup> World Health Organization (WHO) antenatal care recommendations include an ultrasound scan as a part of routine antenatal care (one ultrasound scan before 24 weeks' gestation is recommended for pregnant women to estimate gestational age, improve detection of fetal anomalies and multiple pregnancies, reduce induction of labor for postterm pregnancy, and improve a woman's pregnancy experience).<sup>3</sup>

The impact of routine ultrasound imaging in terms of significantly improving the overall pregnancy outcome (maternal, fetal, and neonatal impacts) has been disputed by recent Cochrane review based on trials conducted mostly in developed countries with well-organized healthcare, proper sanitation and immunization, safe access to the cesarean delivery and political stability.<sup>4</sup> When ultrasound is used in high-risk pregnancies, its use becomes clearly beneficial.<sup>5</sup> However, the fatal pregnancy

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outcomes (stillbirth, maternal and early neonatal death) as end points are considerably rare in developed countries, while it must be highlighted that developing countries account for 99% of maternal and neonatal mortality. Also, considering the fact that there are no sufficient studies conducted in developing countries, particularly in rural settings and high-risk pregnancies, it is still unclear whether some positive impact as described in developed countries will produce similar results in low-income countries with specific problems and needs.

The potential to reduce maternal and neonatal deaths with the use of ultrasound is significant and addresses two of the Millennium Development Goals (MDGs) including MDG 4 which aims to reduce child mortality and MDG 5 aiming to improve maternal health.<sup>6</sup>

This review not only provides further evidence of the promising potential of the use of ultrasound in resource-limited settings but also addresses some critical issues of maternity care in developing countries. Also, certain proposals and ideas about how to implement ultrasound in clinical practice to reduce maternal and neonatal mortality will be discussed.

## TRAGIC FACTS—MATERNAL AND PERINATAL MORTALITY

Before discussing about the possible role of obstetric ultrasound implementation in reducing maternal and perinatal mortality in a developing country, it is essential to display basic (and tragic) statistical facts. Approximately 295,000 women died in 2017 from preventable causes related to pregnancy and childbirth. Although the maternal mortality ratio (number of maternal deaths per 100,000 live births) dropped by about 38% worldwide between 2000 and 2017, 99% of all maternal deaths still occur in low-income and lower middle-income countries and most of these fatalities could have been prevented.<sup>7</sup>

Sub-Saharan Africa and Southern Asia accounted for approximately 86% (254,000) of the estimated global maternal deaths in 2017. Women in less developed countries have, on average, many more pregnancies than women in developed countries, and their lifetime risk of death due to pregnancy is higher. A woman's lifetime risk of maternal death is the probability that a 15-year-old woman will eventually die from a maternal cause. In high-income countries, this is 1 in 5,400 vs 1 in 45 in low-income countries. The major complications that account for nearly 75% of all maternal deaths are postpartum hemorrhage and other delivery complications, infections (usually after childbirth or abortion), pregnancy-related hypertensive disorders (preeclampsia and eclampsia), and consequences of unsafe abortion. The remainder are caused by or associated with other infections such as malaria or related to chronic conditions such as cardiac diseases or diabetes.<sup>8</sup> Poverty, low educational level, restrictive abortion policy, climate changes, lack of transportation, and skilled birth attendants are contributory factors for this statistical tragedy.

Developing countries have also reported high perinatal mortality globally. The situation is again particularly critical in sub-Saharan Africa where most countries have a poor health services due to conflicts, poverty with lack of proper infrastructure, and lack of political commitment. Recent study reported perinatal mortality rate of 34.7 per 1,000 births in sub-Saharan Africa.<sup>9</sup> After meta-analysis of demographic and health surveys to quantify perinatal mortality rate, the authors concluded that strategy to reduce perinatal mortality should be focused on community-based mobilization of women to seek adequate antenatal care services and facility-based deliveries, as well as improved nutrition, up-to-date immunizations and healthy water, sanitation, and hygiene practices.

## ULTRASOUND TO PREVENT SEVERE PREGNANCY COMPLICATIONS, IS THERE A SCIENTIFIC EVIDENCE?

Ultrasound during antenatal care is proposed by WHO as a strategy for increasing hospital deliveries for complicated pregnancies and improving maternal and neonatal outcomes in low- and middle-income countries. The introduction of various interventions without proof of efficacy in achieving an important clinical outcome is common in obstetrical practice.

The first look study<sup>10</sup> (referenced in the WHO recommendations) was a randomized trial conducted in the Democratic Republic of Congo, Guatemala, Kenya, Pakistan, and Zambia to evaluate the impact of ultrasound on pregnancy outcomes. It subsequently showed that the routine use of ultrasound during antenatal care

in rural, low-income settings did not improve maternal, fetal, or neonatal mortality, nor did it increase women's use of antenatal care or the rate of hospital births. During the study, fewer women than expected completed referrals for additional care (73%). Strikingly, the need for approval of the baby's father was both a facilitator for those who attended a referral visit and a barrier for those who did not.<sup>11</sup>

One reason that the first look study of routine use of ultrasound during antenatal care may have failed to improve maternal, fetal, or neonatal mortality could be that the conditions screened by ultrasound may not present enough risk, even if appropriately treated, to have influenced these outcomes. Furthermore, ultrasound is diagnostic in nature and while its ability to diagnose may be apparent, without the ability to utilize that information to improve an important outcome, introducing that test into practice will not be of benefit.<sup>11</sup> For such reasons, specific goals should be better defined, barriers of implementation should be eliminated, and continuum of care should be provided.

However, several studies have demonstrated the beneficial impact of ultrasound on the pregnancy outcome (both maternal and neonatal).

The results of the study of Wastlund et al. demonstrated that the universal late pregnancy ultrasound in nulliparous women would virtually eliminate undiagnosed breech presentation.<sup>1</sup> Also, the use of universal ultrasound in late pregnancy (36 weeks) would be expected to reduce fetal mortality in breech presentation and avoid unnecessary emergency cesarean sections. Similar research has not been conducted in low-income countries, but one may assume that the benefit would also be applicable for developing countries.

The diagnostic impact of limited, screening obstetric ultrasound performed by midwives in rural Uganda demonstrated that obstetric ultrasound altered the clinical diagnosis in up to 12% clinical encounters.<sup>12</sup> Focused 6-week limited obstetric training improved diagnosis of early pregnancy complications as well as later gestation twins and malpresentations with high sensitivity and specificity. Of all cases screened in the first trimester, there were 16% cases in which ultrasound diagnosis has altered the treatment. As an example, there were 4% of cases with molar pregnancy, which when undiagnosed and untreated may be a life-threatening condition. Also, a substantial proportion of placental malposition, non-cephalic presentations in singleton pregnancies, and the diagnosis of multiple gestation have been documented.

Furthermore, a study of Kozuki et al. demonstrated that sonographic findings altered the patient care plan up to 86% when limited obstetric ultrasound has been used selectively by allied health workers to clarify a clinical concern.<sup>13</sup> The use of ultrasound may affect patient management plans especially regarding potential surgical interventions (e.g., cesarean delivery for PP or surgical procedure for the retained products of conception after miscarriage or delivery).

The impact of structured and short training of the auxiliary nurse-midwives in Nepal on identification of selected third-trimester obstetric risk factors using ultrasonography was assessed in the Nepalese study.<sup>13</sup> Three auxiliary nurse-midwives received two 1-week ultrasound trainings at Tribhuvan University Teaching Hospital in Kathmandu. At a study site in rural Nepal, pregnant women who were 32 weeks of gestation or greater were enrolled and received ultrasound examinations from the auxiliary nurse-midwives during home visits. This study demonstrated the high accuracy in diagnosis of non-cephalic presentation, multiple

gestation, and PP. Of importance, the authors estimated that 160 perinatal deaths may be averted during 5 years for 15,000 births in a catchment area of 100,000 in population with early diagnosis—a cost of \$65 per life saved.

In conclusion, it is clear that the impact of ultrasound on the reducing maternal and perinatal mortality is promising. However, each low-income country and community should define their own priorities which may be different for urban and rural populations, produce local guidelines for screening and management for specific obstetrical situation, and develop strategies for monitoring outcome and developing further strategies to evaluate further measures.

Examples of targets and the potential benefit of ultrasound examination in reducing pregnancy-related complications are displayed in Table 1.

## ULTRASOUND FOR DIAGNOSIS AND MANagements OF CERTAIN HIGH-RISK PREGNANCIES AND PREGNANCY COMPLICATIONS WITH SPECIAL EMPHASIS TO SUB-SAHARAN AFRICA

### Complications of Abortion

An estimated 93% of women of reproductive age in Africa live in countries with restrictive abortion laws. Even in countries where the law allows abortion under limited circumstances, it is likely that few women are able to obtain a safe, legal procedure.<sup>14</sup> Africa is the world region with the highest number of abortion-related deaths. In 2014, at least 9% of maternal deaths (or 16,000 deaths) in Africa were from unsafe abortion. In all, about 1.6 million women in the region are treated for such complications each year.<sup>15</sup> The most common complications from unsafe abortion are incomplete abortion, excessive blood loss, and infection. Incomplete prolonged spontaneous abortion with residual product of conception (RPOC) may cause hemorrhage and sepsis and thus may increase maternal morbidity and mortality. The diagnosis and appropriate management of RPOC are of essential importance.

Durfee et al. have demonstrated that endometrial mass is the most sensitive finding for the diagnosis of RPOC.<sup>16</sup> If no mass or endometrial fluid is seen and the endometrial thickness is less than 10 mm, RPOCs are extremely unlikely. The absence of blood flow does not exclude the diagnosis of RPOCs.

Melese et al. conducted the retrospective institution-based cross-sectional study at four hospitals in Botswana (where induced abortion is illegal) to assess the patterns and determinants of postabortion complications.<sup>17</sup> Of 619 patients, the majority of abortions (95.5%) were reported to be spontaneous and 3.9% of the abortions were induced by the patient. There were a total of nine abortion-related deaths with a case fatality rate of 1.5%. Self-induced abortion and delayed uterine evacuation of more than 6 hours were found to have significant association with postabortion complications. The results of this study emphasize the need for changing of legislation, better care in providing contraception counseling, and needs for follow-up in cases of prolonged bleeding and other complications following spontaneous abortion. Ultrasound to detect RPOC may play the major role. The importance of the ultrasound examination in detecting RPOC was highlighted also in the Pakistanian study.<sup>18</sup>

**Table 1:** Examples of targets and the potential benefit of ultrasound examination in reducing pregnancy-related complications

Target	Benefit of ultrasound examination
Diagnosis of pregnancy	<ul style="list-style-type: none"> <li>Identifying high-risk pregnancies and enable referral for surveillance and institutional delivery</li> <li>Modifying lifestyle</li> <li>Screening for fetal anomalies, preterm birth, preeclampsia, gestational diabetes, and other pregnancy-related complications</li> </ul>
Determination of gestational age	<ul style="list-style-type: none"> <li>Avoiding iatrogenic inductions of labor</li> <li>Avoiding stillbirths</li> <li>Optimization of antenatal steroids and magnesium sulfate administrations for selected pregnancies</li> </ul>
Diagnosis of twin pregnancy	<ul style="list-style-type: none"> <li>Advanced pregnancy care</li> <li>Referral to the institutional delivery</li> <li>Diagnosis of monochorionic twin pregnancy and advanced pregnancy surveillance (in more advanced settings)</li> </ul>
Uterine fibroids	<ul style="list-style-type: none"> <li>Prepregnancy counseling</li> <li>Pregnancy follow-up</li> <li>Avoiding unnecessary laparotomy and preterm delivery in nondiagnosed cases</li> <li>Referring for the safe cesarean delivery in cases of myomas previa</li> </ul>
Placenta previa	<ul style="list-style-type: none"> <li>Awareness of pregnancy complications (bleeding and anemia)</li> <li>Organizing antenatal care and safe elective cesarean delivery</li> <li>Optimization of antenatal steroid administration</li> <li>Screening for abnormally invasive placenta (in more advanced settings)</li> </ul>
Retained product of conception after miscarriage or induced abortion	<ul style="list-style-type: none"> <li>Avoiding unnecessary surgical procedures</li> <li>Providing misoprostol for nonsurgical evacuation</li> <li>Prevention of anemia and sepsis</li> </ul>

However, the operator and equipment variables need to be looked at, and a uniform criterion needs to be agreed on. Additionally, results from a randomized trial in Burkina Faso demonstrated that 600 µg of oral misoprostol is as safe and acceptable as manual vacuum aspiration (MVA) for the treatment of incomplete abortion in a developing country setting.<sup>19</sup> Of note, because of the time-consuming and costly nature of training providers at all the provincial and rural levels, combined with the difficulty of maintaining an adequate stock of MVA equipment and supplies, MVA has not been able to achieve its promise as a

sustainable treatment for incomplete abortion. For these reasons, invasive surgical dilatation and curettage, with its higher rate of complications, including infection, continues to be practiced.

The poorest women with the fewest resources are most likely to experience complications from unsafe abortion. Unsafe abortion has negative consequences beyond its immediate effects on individual women's health. Diagnosis and treating complications increase the economic burden on poor families and incur considerable costs to already struggling public health systems.<sup>20</sup>

One of the solutions would be extended use of misoprostol not only for medically induced abortion but also for the uterine evacuation after prolonged bleeding and ultrasound-proven residua.<sup>20</sup> This would reduce the need for surgical interventions and most probably reduce the complication rates. The extent to which misoprostol is used to induce abortions in Africa is not known; however, the sale of misoprostol has increased in some African countries in recent years.<sup>20</sup>

In most low-income and middle-income countries, more women are overweight or obese. The cross-sectional demographic and health surveys from 27 sub-Saharan countries (2003–2009) showed an association between maternal obesity and the death of the most recent infant during the neonatal period.<sup>21</sup> If confirmed with longitudinal research, obese African women should be encouraged to lose weight before pregnancy and be strongly advised to deliver in a facility capable of providing emergency care. Body mass index (BMI) is projected to rise substantially in sub-Saharan Africa over the next few decades and demand for cesarean sections already exceeds available capacity. Culturally appropriate prevention strategies to discourage further population-level rises in BMI need to be designed and implemented.<sup>22</sup>

### Placenta Previa and Abnormally Invasive Placenta

Placenta previa is a clear risk factor for obstetric hemorrhage, which is a major cause of fetomaternal morbidity and mortality in developing countries.<sup>23,24</sup> Placenta previa is a classical indication for cesarean delivery. Placenta previa may be the synonym for the death sentence in remote rural settings without access to the ultrasound diagnosis, surveillance, and access to the cesarean delivery. It has been also demonstrated that both types of PP (minor and major) are equally serious conditions and risk factors for abnormally invasive placenta that usually occurs in pregnancies with PP and previous uterine surgery.<sup>25</sup> Ultrasound has been proven as a simple and reliable tool to diagnose PP and increase suspicion of abnormally invasive placenta.<sup>25</sup>

A study from Tanzania that investigated adverse fetomaternal outcomes of PP in 270 cases demonstrated, among other neonatal adverse outcomes, clearly increased odds for the stillbirth and early neonatal death.<sup>23</sup> Inadequate antenatal care without antenatal diagnosis of PP was associated with poorer neonatal outcome. A retrospective study from India that sought to investigate frequency, demographic characteristics, indications, and fetomaternal outcomes associated with emergency peripartum hysterectomy in an easily accessible urban center showed tragic facts.<sup>26</sup> Maternal mortality in this cohort was 17.7%, whereas perinatal mortality was 37.5%. Of note, 21% of hysterectomies have been performed due to the intractable postpartum hemorrhage in cases of abnormally invasive placenta.<sup>26</sup>

The incidence of abnormally invasive placenta increases dramatically with the number of previous cesarean sections. As availability of cesarean section in developing countries is improving,

it is to be expected that the incidence of the abnormally invasive placenta will also increase in such settings. This may contribute further to the maternal and neonatal mortality.

### Twins

Sub-Saharan Africa has the highest rate of naturally occurring twin births in the world. Twins are extremely vulnerable and twin births and twin pregnancies have a high risk of complications for mother and child. Twins suffer from antepartum and intrapartum stillbirth, low birth weight, preterm delivery, and poorer neurodevelopmental outcome compared with singletons. Twin pregnancies and births are associated with obstetric complications such as anemia, postpartum hemorrhage, hypertensive disorders, and increased maternal mortality.<sup>27</sup>

The most significant finding of the study that investigated maternal and perinatal outcomes of twin pregnancy in 23 low- and middle-income countries was increased prevalence and adjusted odds of severe adverse maternal outcomes and perinatal mortality in twin pregnancies compared with singleton pregnancies, regardless of the mode of delivery.<sup>28</sup> The study from Nigerian tertiary hospital showed similar results.<sup>27</sup>

An important observation emerged from the study of Bellizzi et al.<sup>29</sup> Data from 60 low- and middle-income countries that included 14,312 twin births showed that cesarean section was associated with a significant protective effect in twins (odds ratio = 2.1; 95% confidence interval = 1.5–3.1). However, when stratifying by national cesarean section rates, the significance remained only in the countries where the rate of cesarean section was 15% or higher. The authors concluded that institutional deliveries and increased access of cesarean sections may be considered for twin pregnancies in low- and middle-income countries to decrease early adverse neonatal outcomes. There are historical reports that even in the setting of high-income countries, up to 10% of twin pregnancies remained clinically undiagnosed until the second stage of labor.<sup>30</sup> This percentage may be even higher in low-income countries due to the lack of experience, higher rate of growth restriction, or maternal obesity that is a matter of concern also in sub-Saharan Africa.<sup>31</sup>

This emphasizes the role of antenatal ultrasound in detection and surveillance of twin and other multiple pregnancies.

### Uterine Fibroids

It has been estimated that the prevalence of uterine fibroids in African women is up to 20%, which is much higher than in women of other ethnic origins. Uterine fibroids of significant size are easily demonstrated during the basic ultrasound scan. Pregnant women with uterine fibroids are at increased risk for cesarean delivery, breech presentation, malposition, preterm delivery, PP, and severe postpartum hemorrhage.<sup>32</sup> The most important factors in determining morbidity in pregnancy include fibroid number, size, location, and relationship to placenta implantation. Women with fibroids 10 cm or larger achieve a vaginal delivery rate of nearly 70%, unless it is completely obstructing birth channel. These facts are useful for preconception and prenatal counseling of women with leiomyomas.

The majority of pregnancies with uterine myomas will proceed without complications. However, it has been demonstrated that 10–30% of pregnant women with myomas develop various complications during gestation, labor, or delivery, based on their localization and dimension, which are important prognostic elements.<sup>33</sup> Although some studies strongly suggest the safety



of cesarean myomectomy, data on the long-term outcomes of cesarean myomectomy in women are lacking. Seffah presented a retrospective analysis on 44 re-laparotomies following cesarean section at the Korle Bu Teaching Hospital in Accra, Ghana.<sup>34</sup> Of 17 hysterectomies, 3 were performed due to bleeding from myomectomy. The fatality rate was 9% (4/44), and one of those cases involved cesarean section for transverse lie during which myomectomy was performed. Due to inadequate hemostasis, re-laparotomy and hysterectomy were performed, but the patient died 12 hours after reoperation. The risk–benefit ratio of cesarean myomectomy should be reevaluated in large studies, given the increasing patient age, incidence of myoma in pregnancy, and the wide use of assisted reproductive techniques.<sup>35</sup>

Unfortunately, old myths, beliefs, and misconceptions also still exist concerning the treatment of uterine myomas. A Nigerian study has demonstrated that acquired gynatresia was more common in Lagos than congenital gynatresia.<sup>36</sup> Of 39 patients (83.0% of all) presented with acquired gynatresia, the main cause of which was herbal pessaries (30 patients, 76.9%). Herbal pessaries were used to treat fibroids (23 patients, 76.7%), uterovaginal prolapse (3 patients, 10.0%), and infertility (2 patients, 6.7%) and to procure abortion (2 patients, 6.7%). These are tragic facts, and there is a lot of work ahead to overcome misconceptions and improve counseling a treatment.

### Access to the Safe Cesarean Delivery

Maternal mortality after cesarean delivery in Africa is 50 times higher than that in high-income countries and is driven by peripartum hemorrhage and anesthesia complications.<sup>37</sup> The neonatal mortality rate after cesarean delivery is also high at 44 per 1,000 live births.

Paradoxically, while many high- and medium-income countries are trying to reduce the cesarean delivery rate, in sub-Saharan Africa, the cesarean delivery rate is static at 3–5%. The rate and availability of safe cesarean section remains a priority in Africa. The implementation of ultrasound may certainly contribute in reducing maternal and perinatal mortality by identifying obstetrical issue for which patients should be referred for the elective cesarean delivery.

However, ultrasound is a powerful tool of revealing obstetrical situations that allow normal vaginal delivery avoiding risky cesarean section. Obstructed labor (OL), most commonly treated with cesarean delivery, has been identified as a major contributor to global maternal morbidity and mortality. Alkire et al. used economic and epidemiological modeling to estimate the cost per disability-adjusted life year averted and benefit–cost ratio of treating OL with cesarean delivery for 49 countries identified as providing an insufficient number of cesarean deliveries to meet demand.<sup>38</sup> This study concluded that using the WHO's cost-effectiveness standards, investing in cesarean delivery can be considered “highly cost-effective” for 48 of the 49 countries included in this study. Furthermore, in 46 of the 49 included countries, the benefit–cost ratio was greater than 1.0, implying that investment in cesarean delivery is a viable economic proposition. Although cesarean delivery alone is not sufficient for combating OL, it is necessary, cost-effective by WHO standards, and ultimately economically favorable in the vast majority of countries included in this study.

The study of Barageine et al. was conducted to identify risk factors for obstetric fistula in western Ugandan context.<sup>39</sup> Among other factors, prolonged labor and weight of the baby of 3.5 kg or more were identified as risk factors for obstetric fistula. Intrapartum

ultrasound not only provides objective and quantitative data in labor, thus expanding knowledge about the pathophysiology of abnormal labor, but also improves the obstetric outcomes of both the mother and fetus as a supplementary tool for active management.<sup>40</sup>

This calls for vigilant screening for fetal size by well-trained/skilled midwives assessing the pelvis and the use of ultrasound to identify large babies followed by a planned delivery and extra monitoring.

## HOW TO IMPROVE THE IMPLEMENTATION OF OBSTETRIC ULTRASOUND?

### Donations of Ultrasound Devices

Nowadays, ultrasound devices have become smaller, more portable, and durable, and the cost (purchase and maintenance) has decreased dramatically. The magnitude of compact ultrasound donations to medical facilities in low-resource countries is not known, although it certainly exists. Harris et al. conducted a survey after compact ultrasound units were donated to rural and urban clinics in low-resource sites to identify the scope, locations, characteristics, and outcomes of completed donations.<sup>41</sup>

Forty-eight ultrasound devices were donated to 15 different nations on 4 continents, Uganda accounted for 40% of all donations. All but four sites received initial training of different content and duration. Hands-on training has been in most locations directly provided by members of the donation team, and in several instances, ongoing training remained the responsibility of local sonographers. Educational material included recorded courses or lectures on CD or DVD, PowerPoint presentations, textbooks, manufacturers' manuals, and remote electronic review of transmitted images. The survey revealed that the donated devices had impressive durability, especially in light of the less-than-ideal settings in which they are used. In terms of applications, the responses indicated that in addition to the expected application in obstetric and gynecologic uses, the ultrasound devices are being used for various other diagnostic purposes, chiefly, abdominal, trauma, and breast cancer detection.

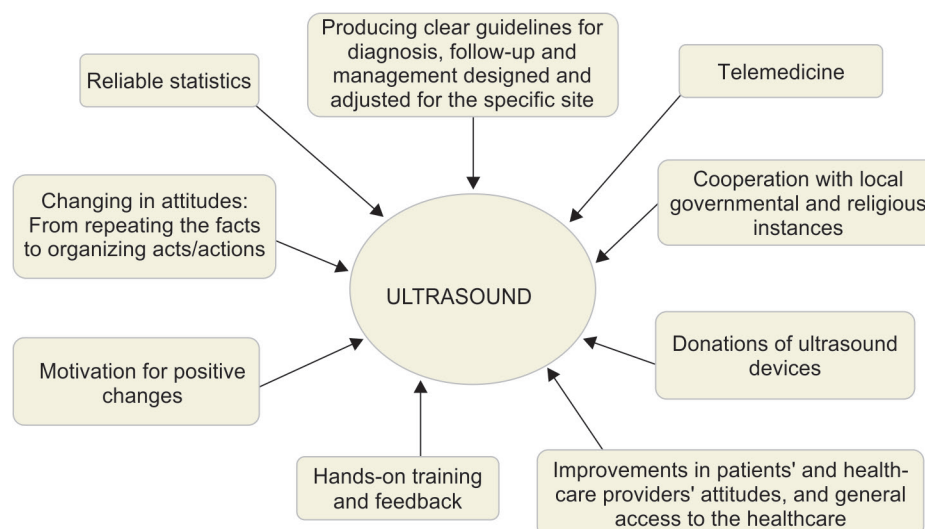
The authors concluded that even in its current state (limited, dispersed, and poorly coordinated), individual and small-group initiatives may represent a low-cost and effective approach to help establishing basic ultrasound imaging in low-resource regions with the enormous scale of the public health need. However, the authors also emphasize the need for the action on larger scale, coordination, and well-structured feedback to provide improvement based on proper insight into the impact of such activities on the well-defined goals.

### Telemedicine

Telemedicine has been integrated into numerous domains of medicine and has enabled high-quality care despite of obstacles of geographic distance, limited access to healthcare providers, and shortage of financial resources. This modality of healthcare delivery from a distance has evolved tremendously during the past five decades. Ultrasound application within telemedicine (“teleultrasound”) has been a successful story, particularly in high-income settings. However, there is paucity of data about the utility of teleultrasound in resource-limited settings.

The first systematic review of the literature to determine whether remote teleultrasound is a feasible and accurate imaging

**Flowchart 1:** Background “infrastructure” required for the successful implementation of obstetric ultrasound in low-income countries



modality that alters the care provided to patients in resource-limited settings compared with the standard of care has been conducted by Britton et al.<sup>42</sup> This review included 12 rigorously selected publications, of which 4 studies primarily involved obstetrics. Although ultrasonographers included physicians and midwives without prior obstetric ultrasound training, none of the obstetric studies used remote telementored ultrasound (RTMUS) that utilizes a single centrally located physician trained in bedside ultrasound who guides a geographically removed bedside provider in image acquisition and performs image interpretation from afar. The results of the studies showed that ultrasound acquired accurate fetal structural views, allowed for the modification of perinatal care, and helped facilitate transfer to specialty centers when needed.

The authors also concluded that RTMUS is particularly relevant in low- and middle-income countries, where a scarcity of physicians often exists. Task-shifting ultrasound performance away from formally trained sonographers and physicians to nonexperts, while maintaining high-quality imaging, helps establish a sustainable and cost-effective telemedicine programs.

## CONCLUSION AND FUTURE DIRECTION

There is no doubt about the benefits of introducing ultrasound in the management of the pregnancies in low-income countries. However, the ultimate goal of reducing considerably high maternal and perinatal mortality cannot be achieved only by this safe and relatively cheap screening and diagnostic method. Its value will be of limited until specific goals (who? how? when? where?) are defined. Furthermore, barriers to use of ultrasonography (availability of devices, costs, infrastructure, education, cultural misperceptions, and legislation) should be overcome. Background “infrastructure” required for the successful implementation of obstetric ultrasound in low-income countries is displayed in Flowchart 1.

As approximately 40% of fetal, neonatal, and maternal deaths occur during the intrapartum period or on the day of birth, early diagnosis of risk factors for intrapartum-related complications and subsequent referral for care have been highlighted as key strategic research priorities for low- and middle-income countries by public health experts.

Having targets for mortality reduction is important, but accurate measurement of maternal and neonatal mortality remains

challenging, and many deaths still go uncounted. Many countries still lack well-functioning civil registration and vital statistical systems, and where such systems do exist, reporting errors—whether incompleteness (unregistered deaths, also known as “missing”) or misclassification of cause of death—continue to pose a major challenge to data accuracy. Each death counts!

As scientific approach is of essential important, future trials on the role of ultrasound in reduction of maternal and neonatal mortality should be extremely well and carefully designed with the simple and important outcome end points.

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